

Fisheries Long Term Monitoring Program

Summary of spotted mackerel
(*Scomberomorus munroi*) survey
results: 2004–05

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Acronyms

CFISH	Commercial Fisheries Information System, DPI&F
DPI&F	Department of Primary Industries and Fisheries, Queensland
FL	fork length
JL	upper jaw length
LTMP	Long Term Monitoring Program, DPI&F

Summary

Spotted mackerel (*Scomberomorus munroi*) is an important species to recreational and commercial fishers along the east coast of Queensland. Previous research, and patterns in the catches of the fishery, indicate that there is a single stock between Cairns and northern New South Wales. The single stock undertakes seasonal migration associated with spawning and feeding.

Peak fishing activity occurs where and when favourable weather coincides with the migration pattern of the species. A trend of increasing commercial catches between the late 1990s and the 2000–01 financial year, followed by a sharp decline during the 2001–02 financial year, led to concerns being raised about the long-term sustainability of the fishery. Some major changes were made to regulations relating to management of spotted mackerel in 2002 and 2003. These changes included increasing the minimum legal size from 500 to 600 mm total length; reducing the recreational bag limit from 30 to 5; placing an annual cap on the commercial catch; and prohibiting the use of nets to target spotted mackerel.

Previous surveys of spotted mackerel have included an extensive Fisheries Research and Development Corporation funded project in the mid 1990s and a small-scale survey under the Department of Primary Industries and Fisheries Long Term Monitoring Program between December 2001 and January 2003. The present survey represents the commencement of a long-term, comprehensive monitoring program for spotted mackerel between Cairns and the Queensland–New South Wales border. The objectives of the new monitoring program are to provide annual estimates of the length, age and sex structure of the commercial and recreational catch. This report presents a summary of the length and sex data for the first year of the monitoring program.

A total of 1904 spotted mackerel, ranging from 490 to 930 mm fork length were measured between September 2004 and May 2005. Most of these fish were caught by commercial fishers in the two most southern regions; Fraser-Burnett and Moreton. This result does not reflect the total size of the commercial catch relative to the recreational catch, or the size of catches south of Bundaberg relative to catches between Cairns and Agnes Water. Instead, it reflects the commencement of sampling after the peak fishing season in northern regions, and also the difficulty in obtaining large numbers of samples from the recreational sector. Sampling in future years will be focusing on collecting a greater number of samples from the regions north of Rockhampton and from the recreational sector.

Overall, the length structure of the catch was similar for both the commercial and recreational sectors of the fishery, particularly in the Moreton region where the sample sizes were high for both sectors. The main difference occurred in the Fraser-Burnett region, where most fish collected from commercial catches were ≤ 660 mm fork length, but most fish collected from recreational catches were ≥ 660 mm fork length. It is likely that differences in the locations at which the sampled catches were taken explained the difference in fish lengths. For example, all of the commercial catches sampled were from inside Hervey Bay, whereas most of the recreational catches sampled were from offshore waters out from Tin Can Bay.

The most interesting result from the current survey was the scarcity of male fish in catches of both sectors of the fishery and in all regions. However, the highly skewed (i.e. low) sex ratio of the catch is not necessarily representative of the entire population, as undersized size classes of spotted mackerel are likely to be either dominated by males, or at least have as many males as females. An increasing likelihood of larger fish being female was found in this survey, as well as previous studies. This is most likely a result of the faster growth rate of females relative to males and also a higher mortality rate of males.

The first year of the new monitoring program for spotted mackerel was moderately successful in obtaining baseline information about the status of the stock, using a fishery dependent sampling regime. The most useful outcome, however, has been the trialling of different strategies for collecting data and samples for the two sectors of the fishery in the different regions.

Long Term Monitoring Program background

The Department of Primary Industries and Fisheries (DPI&F), Queensland, manages the State's fish, mollusc and crustacean species and their habitats. As part of this commitment, DPI&F monitors the condition of, and trends in, fish populations and their associated habitats. This information is used to assess the effectiveness of fisheries management strategies and helps ensure that the fisheries remain ecologically sustainable. DPI&F also uses the information to demonstrate that Queensland's fisheries continue to comply with national sustainability guidelines, so that they may remain exempt from export restrictions under the Australian Government's *Environment Protection and Biodiversity Conservation Act 1999*.

DPI&F initiated a statewide Long Term Monitoring Program (LTMP) in 1999, in response to a need to collect enhanced data for the assessment of Queensland's fisheries resources. The LTMP is managed centrally by a steering committee with operational aspects of the program managed regionally from the Southern and Northern Fisheries Centres located at Deception Bay and Cairns respectively. The regional teams are responsible for organising and undertaking the collection of data to be used for monitoring key commercial and recreational species, and for preparing data summaries and preliminary resource assessments.

A series of stock assessment workshops in 1998 identified the species to include in the LTMP. The workshops used several criteria to evaluate suitability including:

- the need for stock assessment based on fishery independent data
- the suitability of existing datasets
- the existence of agreed indicators of resource status
- the practical capacity to collect suitable data.

Species currently monitored in the LTMP include saucer scallops, spanner crabs, stout whiting, mullet and tailor in southern Queensland and tiger and endeavour prawns and coral reef fish in northern Queensland. Species with statewide monitoring programs include mud crabs, barramundi, spotted and Spanish mackerel and freshwater fish. Various sampling methodologies are used to study each species. The incorporation of fishery independent techniques is preferred, with combinations of fishery dependent and independent techniques being used where appropriate. Data collected in the monitoring program are maintained in a central database in Brisbane.

The primary aim of the LTMP is to collect data for resource assessment (ranging from analyses of trends in stock abundance indices to more complex, quantitative stock assessments) and management strategy evaluations. The greatest value of the growing datasets for each of the species and associated habitats is in the long time series generated by continued sampling, something that is usually required for accurate assessments but is rarely available.

Stock assessment models have already been developed for saucer scallops, spanner crabs, stout whiting, mullet, tailor, barramundi, tiger and endeavour prawns, and spotted and Spanish mackerel. In some cases management strategy evaluations have also been carried out. The data collected in the LTMP have been integral to these activities.

The assessments and evaluations have, in turn, allowed options for improvements to the management of Queensland's fisheries resources to be considered. Enhancements to ongoing monitoring have also been identified, particularly to address the increasing demand for high quality data for dynamic fish population models.

Through the ongoing process of collecting and analysing LTMP data and incorporating these data into regular assessments and refining monitoring protocols as required, DPI&F is enhancing its capacity to ensure that Queensland's fisheries resources are managed on a sustainable basis.

Introduction

Spotted mackerel (*Scomberomorus munroi*) is endemic to northern Australia and southern Papua New Guinea (Collette and Russo 1980). A range of evidence indicates that a single stock exists on the east coast of Queensland (Cameron and Begg 2002). This evidence includes genetic composition, otolith microchemistry, temporal and spatial patterns in spawning, and the results of a tag-recapture program. Patterns in the catches of the commercial fishery (Begg *et al.* 2005) also support a single stock undertaking seasonal migration associated with spawning (Begg 1998) and feeding (Begg and Hopper 1997).

Growth of spotted mackerel is fast but variable, with females growing faster than males (Begg and Sellin 1998). Thus females tend to mature at a similar age (one to two years), but larger size than males (Begg 1998). Spawning occurs in northern Queensland waters between August and October (Begg 1998).

Spotted mackerel is an important species for recreational and commercial fishers. Peak fishing activity occurs where and when favourable weather coincides with the annual migration pattern of the species. Estimates of recreational catch have been made based on the results of Queensland and national recreational fishing surveys in 1995, 1997, 1999, 2000 and 2002 (Begg *et al.* 2005). Several methods were used to collect the data and the uncertainty associated with each annual estimate has been high (e.g. Higgs 2001; Cameron and Begg 2002; Henry and Lyle 2003). Begg *et al.* (2005) re-analysed all the data in a standardised manner, and obtained estimates of total annual recreational catch from Queensland of between 52 t and 265 t (mean of 175 t). The 1997 survey estimate of 424 t was excluded by Begg *et al.* from their assessment modelling because of concerns that it may have been an extreme overestimate.

Estimates of commercial catch of spotted mackerel have been made based on the daily catches recorded in commercial logbooks since 1988. Reported commercial catches increased from less than or approximately 100 t in the late 1980s to mid 1990s, to a peak of 410 t in the 2000–01 financial year (Begg *et al.* 2005). Reported catches were 165 t and 272 t in 2001–02 and 2002–03 respectively (Begg *et al.* 2005), and approximately 100 t in the 2003–04 and 2004–05 financial years (CFISH database, September 2005).

Spotted mackerel are managed under Queensland's *Fisheries Act 1994* and *Fisheries Regulation 1995*. In response to concerns about the sustainability of spotted mackerel stock, some major changes were made to management of the species in 2002 and 2003, impacting recreational and commercial fishers. The minimum legal size limit for spotted mackerel was increased from 500 to 600 mm total length; the recreational bag limit was reduced from 30 to 5 fish per person; an annual cap was placed on the commercial catch (140 t for the 2003–04 fishing season); and the use of nets to target spotted mackerel was prohibited. Prior to 2003, gill nets were the main commercial fishing gear used to catch spotted mackerel. These nets could be used actively or passively, with the former involving sighting and surrounding schools of fish, and with increasing use of power drums and haulers. This technique had become common practice, but was also the most unpopular one with other sectors of the fishery because of the large catches that could be taken in single hauls. Since the changes to management, line fishing has become the main commercial method used to catch spotted mackerel.

A short-term, small-scale monitoring program for spotted mackerel occurred as part of the LTMP between December 2001 and January 2003. The data were collected almost entirely from samples of commercial catches from a limited area, and were incorporated into a major stock assessment for the species in 2004 (Begg *et al.* 2005). The value of the spotted mackerel to recreational and commercial fishers, and the recent major changes to management, increased the need for a structured monitoring program for the species. In August 2004, the LTMP commenced a comprehensive monitoring program for spotted mackerel.

Objectives

The objectives of the LTMP spotted mackerel monitoring are to provide annual estimates of the length, age and sex structure of the commercial and recreational catch.

This report presents a summary of the length and sex structure data collected by the LTMP for spotted mackerel between July 2004 and June 2005.

Methods

Commercial and recreational catches of spotted mackerel were sampled between Cairns and the Queensland–New South Wales border (Figure 1; DPI&F 2005). The planned seasonality of sampling reflected the migratory nature of spotted mackerel, with sampling being intensified in each region to coincide with expected high abundances of spotted mackerel (Table 1). The target number of fish to measure from each sector in each region was set at the start of the 2004 sampling season, based on the estimated size (weight) of historical catches (Table 2; DPI&F 2005).

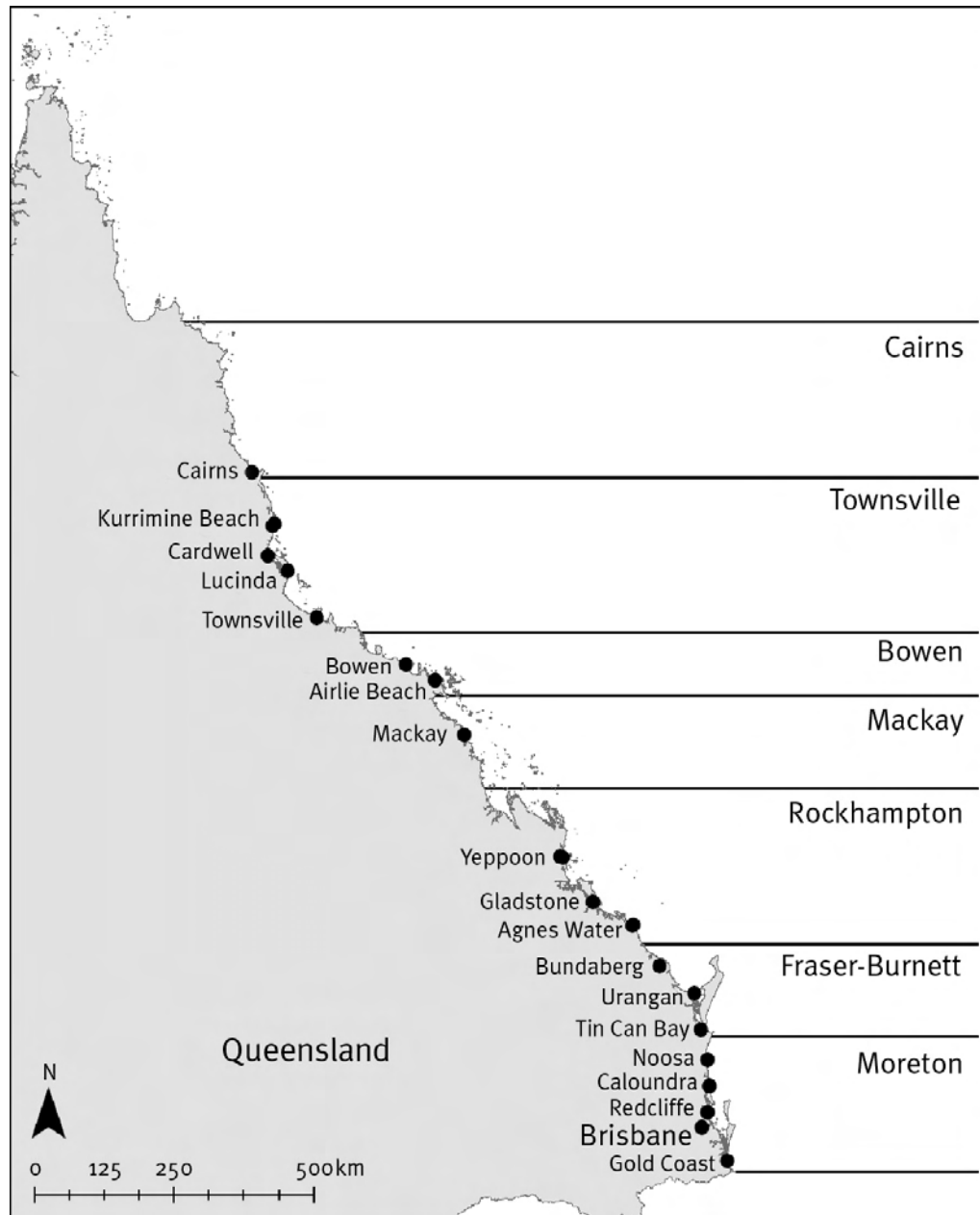


Figure 1. Sampling regions, with major sampling locations, for the spotted mackerel monitoring program.

Table 1. Months designated as peak sampling times for spotted mackerel in different regions.

Region	July	August	September	October	November	December	January	February	March	April	May	June
Townsville												
Bowen												
Mackay												
Rockhampton												
Fraser-Burnett												
Moreton												

Table 2. Target numbers of spotted mackerel to be measured per sector and region based on weighted sampling effort from historical catches and total target sample size of 1800 lengths. Target numbers of individual catches to sample are shown in parentheses.

Region	Commercial		Recreational	
Townsville	100	(8)	82	(41)
Bowen	257	(19)	71	(36)
Mackay	30	(3)	101	(52)
Rockhampton	12	(1)	129	(65)
Hervey Bay	457	(33)	139	(70)
Moreton Bay	253	(19)	171	(86)

The monitoring program for spotted mackerel relies on fishery dependent sampling of the fish population to collect data. A range of different sampling strategies were used to collect the required samples and data. These strategies included:

- asking some commercial fishers to measure fish and occasionally keep samples (e.g. heads and viscera)
- measuring unsorted commercial catches at seafood processors or wholesalers and collecting samples (e.g. heads or fish frames)
- asking recreational fishers to donate samples (fish frames) to the monitoring program
- measuring recreationally caught fish and collecting samples (fish frames) at boat ramps.

The fork length (FL) of spotted mackerel was measured to the nearest 10 mm. Upper jaw length (JL) was also measured (to the nearest 1 mm), so that where FL could not be measured (e.g. if only a head was retained and FL was not recorded), it was estimated from the JL using an empirical relationship between the two measurements. Sex was determined as male or female by macroscopic examination of the gonads.

The number of males and females in catches from each sector and region were estimated by multiplying the proportion of each sex in each length class by the abundance of each length class. Sex ratio is calculated as the proportion of all sexed fish that are male.

Where possible, otoliths (sagittae) were removed, washed, dried and stored. Fish age will be estimated by examining whole otoliths as per LTMP Ageing Protocols (DPI&F In Prep.). Results from ageing 2004–05 samples are not yet complete. These data will be incorporated into a future summary report.

Results

Length frequency

A total of 1904 spotted mackerel, ranging from 490 to 930 mm (FL) were measured between September 2004 and May 2005. Most of these fish were caught in the two most southern regions (Table 3), mainly because sampling did not commence fully until October 2004. By this time, catch rates of spotted mackerel in regions north of Bundaberg were very low. The three most northern regions, Mackay, Bowen and Townsville, have been pooled with Cairns due to the low overall number of fish collected there during the 2004–05 sampling season.

Table 3. Numbers of spotted mackerel measured from each sector in each region during the 2004–05 sampling season. Number of individual catches sampled is shown in parentheses. Note: Cairns, Townsville, Bowen and Mackay regions have been combined.

Region	Commercial		Recreational		Total	
Cairns to Mackay	22	(2)	8	(3)	30	(5)
Rockhampton	7	(4)	30	(12)	37	(16)
Fraser-Burnett	689	(7)	29	(7)	718	(14)
Moreton	759	(46)	360	(75)	1119	(121)
Total	1477	(59)	427	(97)	1904	(156)

The JL was measured for 433 fish between 490 and 930 mm FL (Figure 2). The relationship between the two measurements was:

$$FL = 10.51 \times JL - 30.00$$

This relationship was used to estimate the FLs from JLs of eight spotted mackerel.

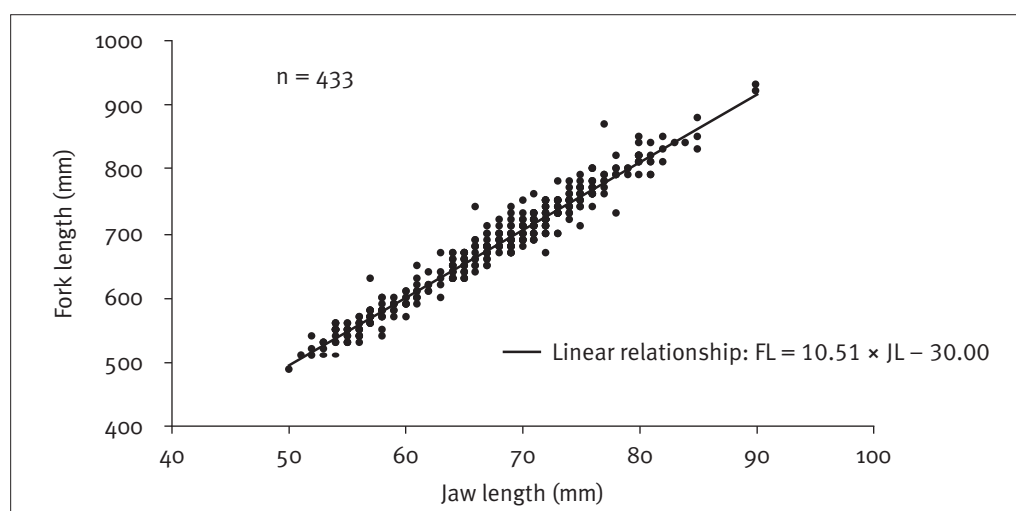


Figure 2. Relationship between fork length (FL) and upper jaw length (JL) of spotted mackerel ($r^2=0.96$).

When the data from all regions were pooled, the size distribution of spotted mackerel in commercial catches was similar to that of the recreational catches (Figure 3). The main notable difference was the high relative abundance of small fish in the 560 and 580 mm size classes (i.e. 560, 570, 580 and 590 mm FL) in commercial, but not recreational catches. This spike resulted from the high relative abundance (64%) of fish in these size classes in the commercial catches in the Fraser-Burnett region (Figure 4). In that region, most fish measured from recreational catches were quite large (e.g. 86% in size classes ≥ 660 mm), whereas most fish measured from commercial catches were quite small (e.g. 86% in size classes ≤ 660 mm).

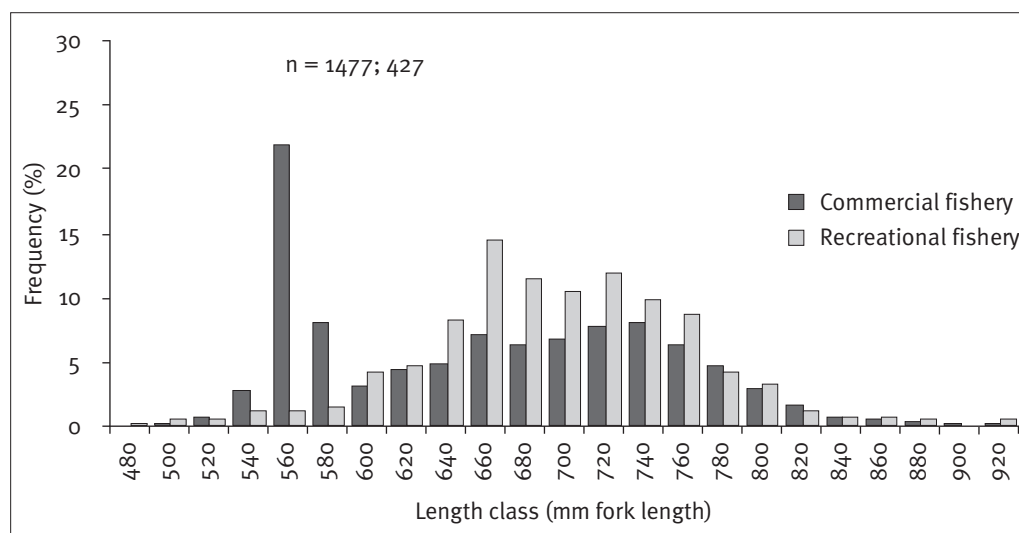


Figure 3. Relative frequencies of spotted mackerel in 20 mm fork length (FL) classes collected from commercial and recreational catches during the 2004–05 sampling season. All regions are combined. Sample sizes (n) are commercial then recreational.

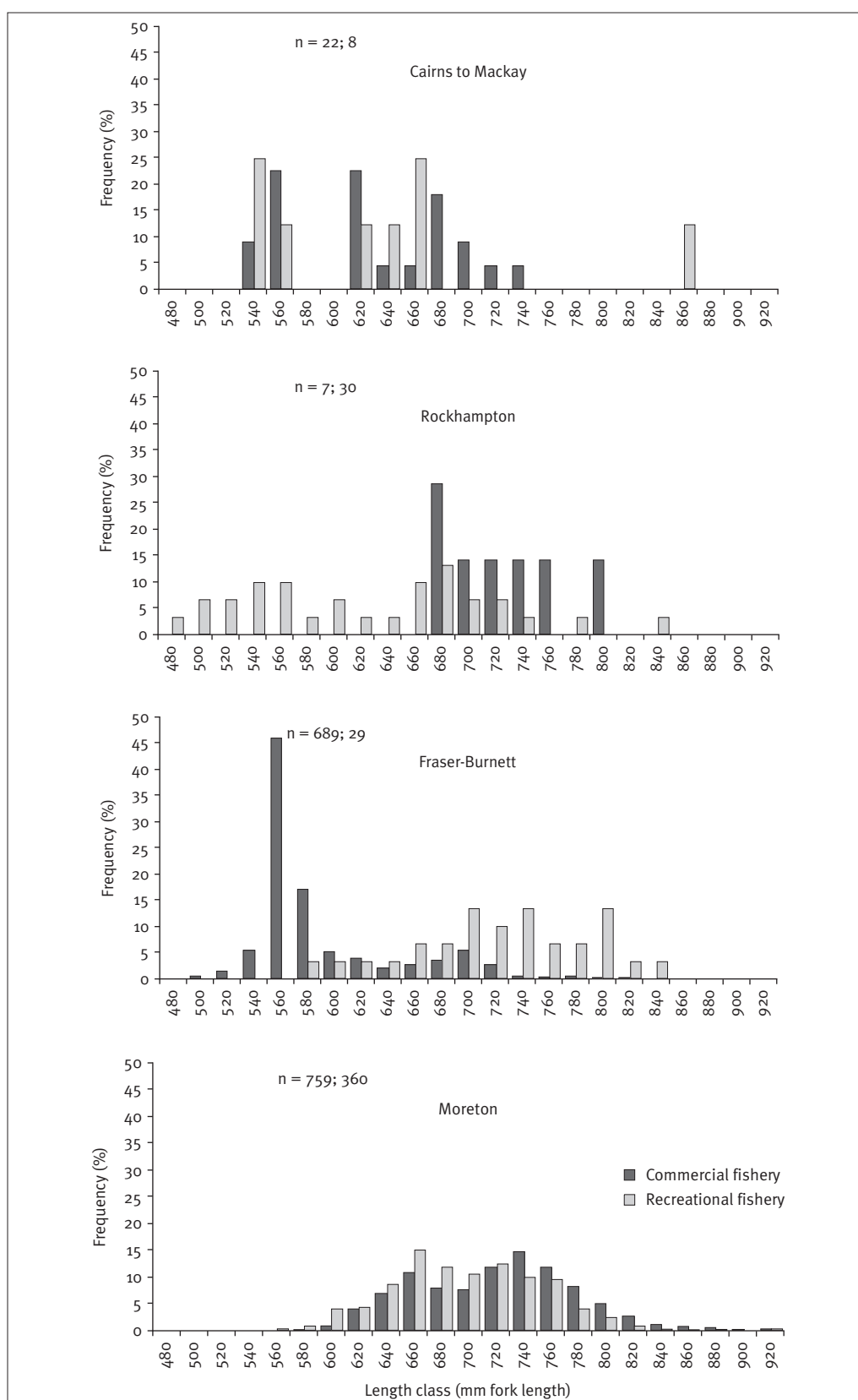


Figure 4. Relative frequencies of spotted mackerel in 20 mm fork length (FL) classes collected from commercial and recreational catches during the 2004–05 sampling season. Sample sizes (n) are commercial then recreational.

In Rockhampton, fish measured from recreational catches were from a wide size range, although most were quite small. For example, 63% were from size classes ≤ 660 mm. In contrast, the seven fish obtained from commercial samples in the region were all in size classes ≥ 680 mm.

The size distribution of spotted mackerel in commercial and recreational catches were most similar in the Moreton region. Additionally, most fish measured from both sectors' catches in that region were quite large. For example, 87% and 81% of fish from commercial and recreational catches respectively were from size classes ≥ 660 mm.

Only a small number of fish were measured from the regions between Cairns and Mackay. There were no obvious patterns in the size distribution of either sector's catch.

Sex ratio

Females were more common in samples than males, although the skewed sex ratio was not consistent for all size classes (Figure 5). There were approximately the same number of males and females in size classes between 500 and 600 mm, then an increasing proportion of females in size classes between 620 and 660 mm. Only one fish larger than 660 mm (740 mm) was identified as male. The dominance of females in most size classes was reflected by the low proportion of males from catches of both sectors in all regions (Table 4).

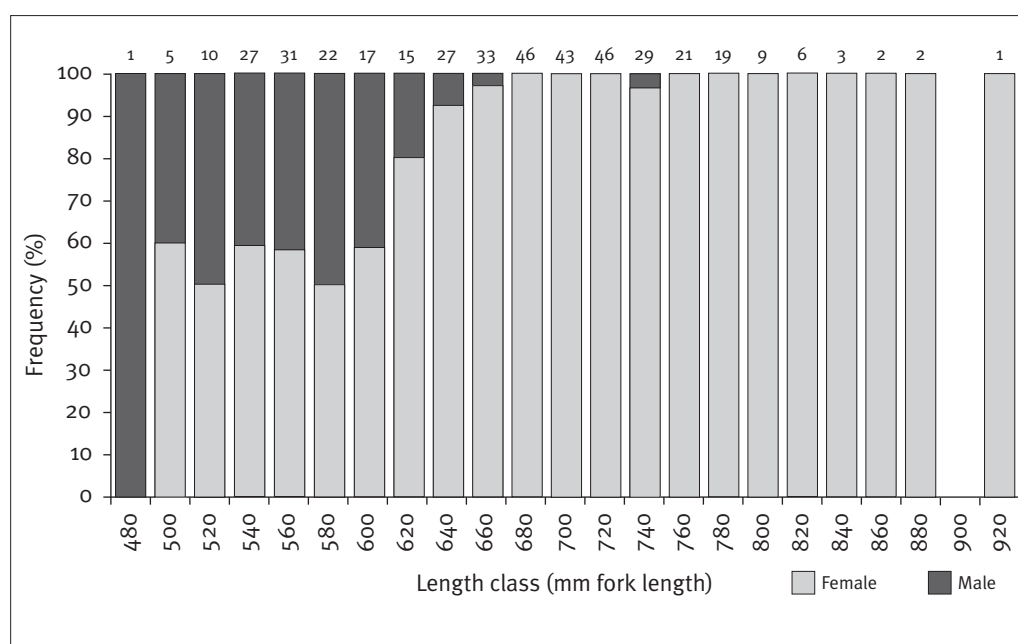


Figure 5. Percentage of male and female spotted mackerel (i.e. sex ratio) in 20 mm fork length (FL) classes. All regions and months are combined. Sample sizes are shown above each bar.

Table 4. Sex ratio for each sector in each region.

Region	Sex ratio male:female	
	Commercial sector	Recreational sector
Cairns to Mackay	0.18	0.20
Rockhampton	0	0.23
Fraser-Burnett	0.35	0.05
Moreton	0.03	0.05

Discussion

Length frequency

For two regions, Rockhampton and Fraser-Burnett, there were clear differences in the size distribution of fish collected from the catches of the recreational and commercial sectors. In Rockhampton, the small number of commercially caught fish tended to be larger than the majority of recreationally caught fish. In contrast, recreationally caught spotted mackerel in Fraser-Burnett tended to be larger than the majority of commercially caught fish. It is possible that differences in line fishing techniques used by different sectors in different regions could have contributed to these differences, as was found for Spanish mackerel by Tobin and Mapleston (2004). They reported differences in the mean size of fish caught by recreational fishers using large and small dead baits, lures and live bait. Like Spanish mackerel, spotted mackerel are caught using a wide range of techniques, such as trolling, spinning and using set lines with live, dead or artificial (lures) baits (Begg *et al.* 2005).

Another factor that contributes to differences in the length structure of the catch is the location at which the fish were caught. In particular, this factor could have contributed to the apparent difference between the size of fish caught by the two sectors in the Fraser-Burnett region. All the fish measured from commercial catches in that region were caught inside Hervey Bay, out from Urangan, whereas most of the fish measured from recreational catches were caught in offshore waters out from Tin Can Bay.

Sex ratio

One of the most interesting results of the present survey was the scarcity of male fish in samples, resulting in highly skewed (i.e. low) sex ratios. While it cannot be ruled out that this is a true reflection of the population's sex ratio, it is more likely that this observation is an artefact of the fishery dependent sampling strategy. For example, the results of this survey demonstrated that the larger a fish is, the more likely it is to be female. The increasing likelihood of fish being females started at 620 mm FL, which is only slightly larger than the minimum legal size for spotted mackerel (600 mm TL, ~520 mm FL). The size classes of fish less than the current minimum legal size are likely to be either dominated by males, or at least have equal numbers of males and females, resulting in a sex ratio of the population closer to 0.5. Interestingly, the recent increase in the minimum legal size of spotted mackerel has contributed to reducing the overall male to female sex ratio of the catch, but not necessarily the population, by eliminating the taking of relatively smaller fish (500–600 mm TL).

The pattern of decreasing male to female sex ratio with increasing size found in this survey was also reported by Cameron and Begg (2002) during the mid 1990s. One of the most likely explanations for this observation is that female spotted mackerel are known to grow faster than males, reaching larger sizes in the same time period (Begg and Sellin, 1998). Male spotted mackerel also appear to have a greater total rate of mortality than females (Cameron and Begg, 2002). Protandry, which is the change of sex of an individual fish from male to female, would also explain the lack of large male fish but is not supported by scientific observations (e.g. Begg 1998).

The results of the current survey differed from those of Cameron and Begg (2002) in two notable ways. Firstly, the smallest size classes in the 2004 LTMP survey had approximately equal numbers of males and females, whereas they were dominated by males in the mid 1990s. Secondly, the size class at which females were consistently more abundant than males was 620 mm in the current survey and 700 mm in the mid 1990s. While the causal mechanisms for these differences are unclear, it is possible that the changes to the management of spotted mackerel—including the increase in the minimum legal size limit, the banning of nets for targeting mackerel and the reduction of the recreational bag limit—have contributed to a shift in the sex structure of the stock.

As with length structure, it is again important to remember that results of the spotted mackerel monitoring program are more a reflection of the catch of the fishery than the population. With sex ratio, it is possible that the difference in the sex structure between the mid 1990s and in the present survey might not reflect changes in the population, but might be a result of changes in fishing techniques. For example, large numbers of net caught spotted mackerel from Hervey Bay and Moreton Bay were examined in the mid 1990s but not in the present survey, when fish were line caught only. It is possible that the different fishing methods have different sex selectivities.

Conclusions

The first year of the new spotted mackerel monitoring program was successful in obtaining baseline information to contribute to future assessments of the status of the stock using a fishery dependent sampling regime. A large number of fish were measured, though mainly from the commercial fishery and mainly from the two most southern regions. This result does not reflect the total size of the commercial catch relative to the recreational catch, or the relative size of catches in the two most southern regions relative to the remaining regions in the sampling area. Instead, it reflects the late commencement of sampling in 2004 after the peak fishing season in northern regions, and also the difficulty in obtaining the target number of samples from the recreational sector.

Perhaps the most useful outcome of 2004–05 mackerel monitoring has been the large number of contacts made in both the commercial and recreational sectors, and also the trialling of different strategies for collecting data and samples in the different regions and for the different sectors.

Future monitoring will be focusing on collecting a greater number of samples from the regions north of Rockhampton and from the recreational sector. Ageing of the otoliths collected in 2004–05 will also be carried out in the near future, once a reference collection has been constructed according to the LTMP ageing protocol (DPI&F In Prep.).

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